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Motion analysis of mini-trampoline jumping: in search of a significant performance measure

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1. Introduction

For a long time research in motor learning has been restricted to the study of rather 'simple' movements, which were performed during strictly controlled laboratory tasks. This approach of motor learning was pursued at the cost of what is nowadays called 'ecological validity'; the behavior of the subjects on experimental tasks was as constrained as making inferences to more complex 'real life' motor skills extremely difficult and speculative.

In compliance with NEISSER's (1976) well-known appeal for research in less constrained behavior, some motor research has recently been redirected at behavior, which is more representative of motor skills displayed in activities like, for example, sport and physical education.

As will be evident from his paper read at this conference, WHITING strongly recommended this change in research strategy opting for an 'operational analysis' of motor behavior. He characterised this approach as lying somewhere between an overrestrained laboratory experimental approach and the study of skills in completely unrestrained every day situations.

Apart from being focussed on more significant skills, 'operational analysis' also involves dependent variables which are more indicative for underlying processes in motor skill learning than single 'outcome' measures featuring in more traditional research (WHITING 1981).

The present paper singles out some aspects of a PhD study carried out by the first author (BAKKER 1981) about the influence of selected personality factors on motor learning in children. In this study an 'operational analysis' of the motor skill in question, a running two-footed jump with extended body from a mini-trampoline (trampette) was carried out. During the learning process several performance aspects of the jumps were measured by means of film analysis. Conceiving these aspects as predictor variables for global expert-ratings of the jumps as a criterion, multiple regression analysis was carried out to find an optimal combination of performance aspects to be used as an operationalization of the quality of the jump.

Results of this analysis are reported here. For further analysis, bearing on the main topic of the study (viz. the relation between personality and performance), the reader is referred to the afore-mentioned thesis of BAKKER (1981).

2. Method

Subjects

Ss were 113 boys (age range 9-14 years) with no prior experience in (mini-) trampoline jumping.

Procedure

All Ss were instructed about the running two-footed jump by way of verbal description and demonstrations by life- and film-models. After being instructed they performed seven blocks of five trials (jumps) each. In between trial blocks breaks of some three minutes were scheduled, during which the experimenter supplied Ss with knowledge of results of their performance.

All jumps were filmed with a recording speed of 56 frames per second. Subsequent motion analysis by an observer resulted in measures for the following eight performance aspects of every jump:

(1) time spent on last two meters of the run ('runtime')
(2) distance between off-take point and trampette ('off-take distance')
(3) height of jump onto trampette ('height onto')
(4) location of coming down into - and taking off from - trampette ('contact point')
(5) height of jump from trampette ('height from')
(6) angle between upper - and lower leg at highest point of jump from trampette ('knee angle')
(7) angle between trunk and horizontal plane at highest point of jump from trampette ('angle trunk')
(8) distance of jump from trampette ('distance jump')

Three expert judges were requested to rate and rerate (interval between first and second ratings being three weeks) the overal impression of each of 210 jumps on a rating scale ranging from 0 (extremely bad performance) to 100 (extremely good performance). The 210 jumps consisted of six series of 35 jumps each. The first series (series 1) was built up by jumps of 35 randomly chosen Ss, one jump being randomly selected from each of these Ss. Each of the remaining series (series 2, 3, 4, 5, and 6, respectively) consisted of all 35 jumps by one of five randomly chosen Ss. Before being rated by the five expert judges the 210 jumps were transmitted from film to video tape.

3. Results

In order to get an indication of the inter-observer reliability of the scoring of the eight afore-mentioned performance aspects, a second observer scored all 35 jumps of one randomly selected S as well. Correlations between scorings of these jumps by both independent observers were greater than .80 for each of the eight measures, indicating a satisfactory inter-observer reliability.

Test-retest reliability (over an interval of two months), as revealed by the correlations between first and second scoring of all 35 jumps performed by two more randomly selected Ss, was good as well: for two observers all eight correlation coefficients in question were greater than .80 for both Ss.

Concerning the reliability of the expert ratings, the following results are pertinent. For five of the six afore-mentioned series test-retest correlations (computed separately for each series and each expert judge) varied from r=.67 to r=.91. For one series of jumps (by one S), however, test-retest correlations were as low as r=.51 and r=.53 for two of the three experts.

Inter-expert correlations ranged from r=.51 to r=.88 with the exception, however, of the latter series (subject), where inter-expert correlations varied from r=.02 to r=.71.

Stepwise multiple regression analysis (MRA) was carried out on the data of series 1 (35 jumps, each jump of a different S), using the expert ratings as criterion variables and the eight measures of performance aspects as predictor variables. The analysis was carried out separately for the first and second ratings of this series by each of the three expert judges. The results of the six MRA's are presented in Table 1 (first ratings) and Table 2 (second ratings).

Tab.1: Stepwise multiple regression analyses on first ratings by experts (A, B, and C) with eight performance aspects as predictors. The analyses are based on data of series 1.

predictor	F-value[x] (to enter)	p<	multiple r	r^2	simple r
Judgement by A					
'Height From'	30.68	.001	.70	.49	.70
'Angle Trunk'	14.18	.001	.81	.65	.40
'Height Onto'	8.35	.01	.85	.73	-.13
All eight variables in the equation			.89	.80	
Judgement by B					
'Height From'	11.77	.01	.52	.27	.52
'Knee angle'	3.71	.07	.59	.35	-.15
All eight variables in the equation			.65	.43	
Judgement by C					
'Height From'	49.33	.001	.78	.61	.78
All eight variables in the equation			.80	.64	

[x] Only predictor variables with F-values (to enter) greater than 2.75 ($p<.10$) are presented.

Tab.2: Stepwise multiple regression analyses on second ratings by experts (A, B, and C) with eight performance aspects as predictors. The analyses are based on data of series 1.

predictor	F-value[x] (to enter)	p<	multiple r	r^2	simple r
Judgement by A					
'Height From'	25.70	.001	.67	.45	.67
'Angle Trunk'	6.77	.05	.74	.54	.31
'Height Onto'	3.94	.06	.77	.60	-.10
All eight variables in the equation			.81	.65	
Judgement by B					
'Height From'	17.21	.001	.59	.35	.59
'Distance Jump'	3.96	.06	.65	.42	.31
All eight variables in the equantion			.69	.48	
Judgement by C					
'Height From'	71.22	.001	.83	.69	.83
'Angle Trunk'	4.45	.05	.85	.73	.19
All eight variables in the equation			.87	.76	

[x] Only predictor variables with F-values (to enter) greater than 2.75 ($p<.10$) are presented.

Inspection of these tables makes clear that the percentage of variance of the expert ratings, accounted for by all eight predictor variables taken together, is smaller for one expert judge (B) than for the other experts (A and C), these percentages for the first and second ratings being respectively 43% and 48% for B, 80% and 65% for A, and 64% and 76% for C.
From all six MRA's it is clear that 'height from' is the best predictor variable, accounting for a substantial percentage of variance of the expert ratings. The latter percentage, however, is again smaller for expert B than for A and C.
The fact that B's ratings cannot be predicted as well as A's and C's may be (partly) due to less consistent ratings by the former expert, for his test-retest reliability was lower than A's and C's (for series 1 the correlation coefficients in question were r=.87 for A, .71 for B, and .84 for C.
Table 1 and 2 also show that no performance aspects account consistently for a significant part of the variance of expert ratings left over after removing the variance accounted for by 'height from'. This suggests that the latter variable is at least as good an operationalization of quality of performance as a measure composed of a composite score of several performance aspects.
The suitability of 'height from' was further born out by the fact that correlation between this aspect and expert ratings for four out of the five series composed of 35 jumps by individual Ss were of the same magnitude as for series 1 (ranging from r=.47 to r=.87 with a median value of .74). For the remaining one of the five series these correlations were much lower (ranging from r=.07 to r=.52). This series is the earlier mentioned one for which both test-retest reliability of expert ratings and inter-expert reliability of these ratings were lower than for the other series. It is clear that the lower the reliability of the criterion, the less well it will be predictable by other variables.

4. Discussion

Two out of three expert judges were shown to be quite reliable in rating overall performance of the running two-footed jump with extended body from a mini-trampoline.
'Height from' accounted for about half of the variance of the ratings of these two experts, this percentage being somewhat smaller in case of the third expert whose ratings were less reliable. Predictions of expert ratings based on 'height from' could not be consistently improved by taking

in other performance aspects. Moreover, the correlations between 'height from' and expert ratings were about as high as the inter-expert reliability of these ratings. So we are lead to the conclusion that ~~Because, moreover, intercorrelations between~~ 'height from' may be used as a simple, but efficient index of quality of performance during the first stages of the learning process.
The latter restriction is, of course, pertinent. In technical descriptions of the jump, height is, indeed, mentioned as one of the main characteristics of a well-performed jump (BONENKAMP, GUNNEMAN, HOLTEN & JAEGERS 1978; KOCH 1962), but other aspects like a large and relatively high jump onto the trampette, an extended body during the 'flight'-phase after taking off from the trampette, and a landing close to trampette are further mentioned as contributing to a good jump. According to verbal report of the three expert judges in the present experiment, they also considered these performance aspects in evaluating the jumps. Our results, however, indicate that evaluations based only on height of the jump from the trampette should lead to broadly the same ratings. It is quite possible that this will not hold true for the judgement of jumps of more experienced performers, where height of the jump might be a much less discriminating feature of performance than other aspects.
Anyhow, for the Ss of the present study height of the jump from the trampette was demonstrated to be a very significant performance measure. Subsequent analysis made clear that it was a useful variable for describing the learning process, which was meaningfully related to personality variables like anxiety and field (in)dependency (BAKKER 1981). The latter findings, however, are beyond the scope of this report.